

A physical/virtual anatomical platform for hysteroscopy training

A. Hernansanz¹, R. Martínez², R. Rovira³, A. Casals^{1,2}

¹Research Centre for Biomedical Engineering, UPC

²Institute for Bioengineering of Catalonia

³Hospital de la Santa Creu i Sant Pau, Barcelona, UAB

albert.hernansanz@upc.edu

INTRODUCTION

Minimally Invasive Surgery (MIS), which consists in operating through small orifices, reduces the patients' pain, complications, recovery time and scarring. However, while providing many benefits, the skills required in MIS are especially difficult to learn. Unfortunately, current training methods for such techniques have not progressed at the same pace as surgical advances. Insufficient surgical skills acquisition translates into complications during procedures, which not only harm the patient, but also increases the derived costs of interventions and their follow up.

Traditionally, surgical skills training consisted in the model „see one, do one, teach one“. This method was practically unchanged until the introduction of simulators, which allow students to practice before entering the operating room, but it still relies on the classical apprenticeship model. Having an expert constantly supervising the training is unsustainable, and the reality faced by residents is the lack of enough practising time [1] [2].

MIS training presents specific challenges that are not addressed by traditional methods. In hysteroscopy, an endoscopic diagnostic and interventional procedure, the hysteroscope is inserted through the vagina and the cervix to examine the uterus. Normally, surgeons have to interpret a 3D operating area through a 2D display monitor, with the consequent lack of depth perception. The instruments, which are introduced through the working channel, provide limited tactile and kinaesthetic feedback, making their control difficult [2].

Current simulators can be divided into two categories: physical simulators, also known as box trainers, and virtual reality simulators. Box trainers consist of anatomical reproductions that can have realistic tactile and visual properties. However, performance assessment has to be carried out by an observer mentor, and therefore, the evaluation is subjective.

Virtual reality simulators offer a wide range of clinical cases and keep track of the performance, but they lack of realistic haptic feedback and physical behaviour. The validity and applicability of skills acquired with virtual simulators is still an open discussion in the scientific and medical community. In addition, there is a noteworthy price difference between the two types, which makes virtual simulators unaffordable for most formative centres [3].

This work presents HysTrainer (HT), a training module for hysteroscopy, which is part of the generic endoscopic training platform EndoTrainer (ET). This platform merges both technologies, with the benefits of having a physical anatomic model and computer assistance for augmented reality and objective assessment. Further to the functions of a surgical trainer, EndoTrainer provides an integral education, training and evaluation platform.

MATERIALS AND METHODS

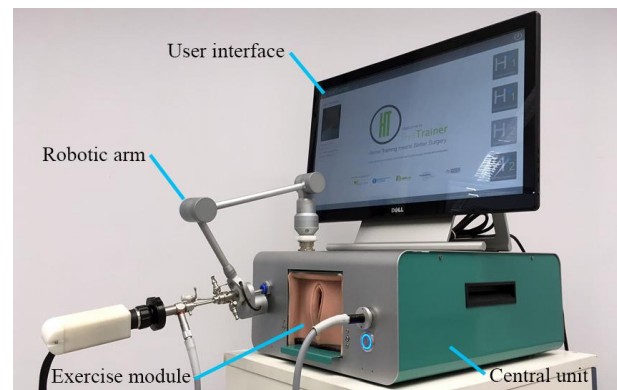


Figure 1. HT parts

Device: ET is a multi-speciality modular training device that can be used for hysteroscopy, cystoscopy and trans-anal surgery. The device consists of a central unit, which connects with the rest of the modules; an exercise module, which contains an anatomic model and elements to train specific skills; a robotic arm, which tracks the movements of the tool inside the anatomic model; and a user interface, which allows the user to interact with the device, visualise the exercise and revise the results.

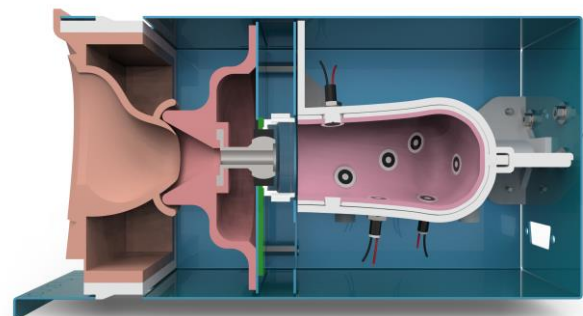


Figure 2. Reaching targets exercise module (section view).

The exercise modules consist of an anatomical model of a female reproductive system built from soft materials that emulate the appearance and physical properties of

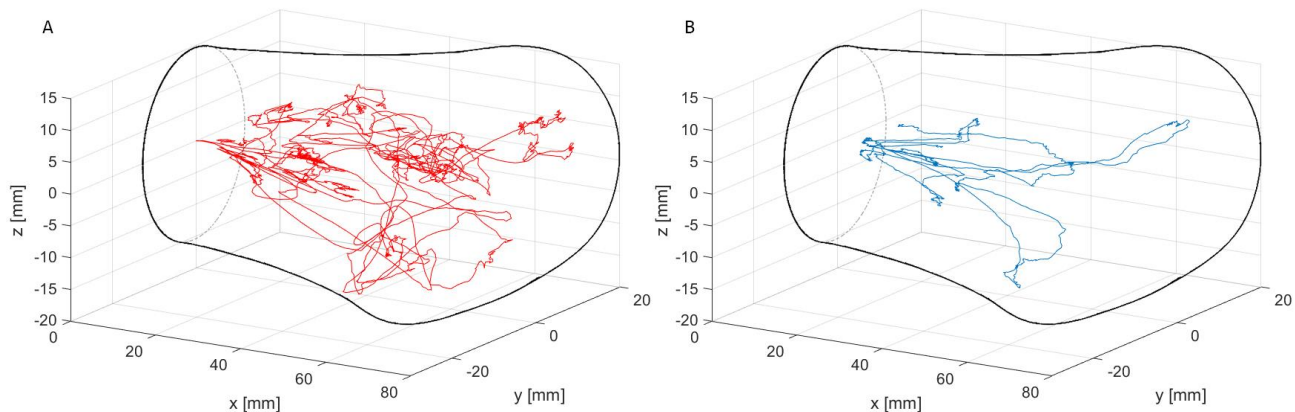


Figure 3. Hysteroscope tip trajectory pattern in the first execution (A) and after 30 repetitions (B) of a user.

the different tissues. They also include sensors and actuators to measure the interaction of the tool with the simulated organ. These modules are independent, and thus, new exercises can be introduced in the future.

The current prototype includes two exercises, corresponding to HYSTT 1-2 from the European Soc. for Gynaecological Endoscopy's formative programme [4]:

- Reaching targets: the user has to reach 10 targets, located in key anatomical points, presented in random order. The exercise aims to train spatial cognition and camera navigation with a 30-degree angle of view hysteroscope. Quantitative metrics are used to assess the performance: time to reach the target; quality, understood as correct positioning and orientation of the tool; and economy of movement, compared to the optimal trajectory.
- Polyp removal: the user has to remove 10 polyps with a micro grasper. This exercise aims to train in the use of auxiliary tools. Each polyp has a sensor to detect when it was extracted and the time spent to reach each polyp is measured.

Testing: the device was tested in the setup shown in Figure 1. The subjects were asked to perform 30 repetitions of the Reaching targets exercise. The tests were conducted with 25 subjects of different expertise level: 16 subjects were novices with no prior experience and 9 subjects were gynaecologists with previous experience in hysteroscopy.

RESULTS

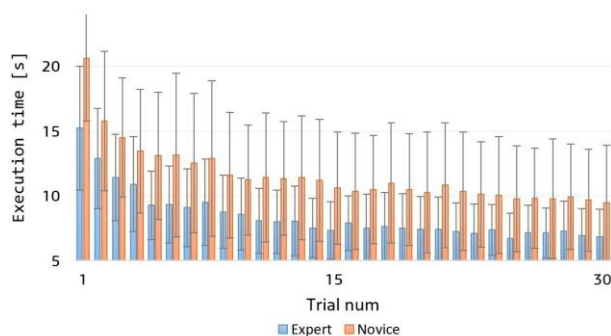


Figure 4. Execution time per target

Figure 3 shows that initially, the user followed random trajectories around the uterus cavity. After 30 repetitions, the user mainly used the central area and diverted the trajectory to reach each target. Using the central channel to observe the uterus denotes mastery in the use of the 30-degree hysteroscope and reduces the risk of harming or perforating the uterus' walls.

Regarding the execution time, the learning curve is stabilised around the 15th trial (figure 4), but there is a reduction in the variance until the last trial in both groups. There is a difference of 11,2 seconds between the 1st and 30th trial in the experts and 8,4 seconds in novices. In all trials, experts needed less time to reach each target.

CONCLUSION AND DISCUSSION

This study proposes a hybrid anatomical platform to train MIS skills applied to gynaecological surgery. The combination of physical and virtual technologies offers the benefits of performing the training exercises in a realistic anatomical model with haptic feedback, while also provides objective measurements and performance assessment.

The proposed training device increases the skills needed to perform MIS in a safe manner. The training proves to be useful regardless of previous experience since both the mean execution time and the dispersion of the results decrease after 30 trials in both groups. The fact that the curves of experts and novices do not intersect also supports the validity of the training.

REFERENCES

- [1] Kolkman W, Wolterbeek R, Jansen FW. "Gynecological laparoscopy in residency training program: Dutch perspectives." *Surg Endosc*; 2005; 19(11):1498-502.
- [2] Janse J, Driessen S, Veersema S, Broekmans FJM, Jansen FW, Schreuder HWR. "Training of Hysteroscopic Skills in Residency Program: The Dutch Experience. *J Surg Educ*; 2014; 72(2).
- [3] Lahanas V, Georgiou E, Loukas C. "Surgical Simulation Training Systems: Box Trainers, Virtual Reality and Augmented Reality Simulators." *Int J Adv Robot Automn*; 2016; 1(2): 1-9.
- [4] HYSTT. Hysteroscopic Skills Training and Testing method, Accessed on 20th December 2018. <https://europeanacademy.org/training-tools/hystt/>